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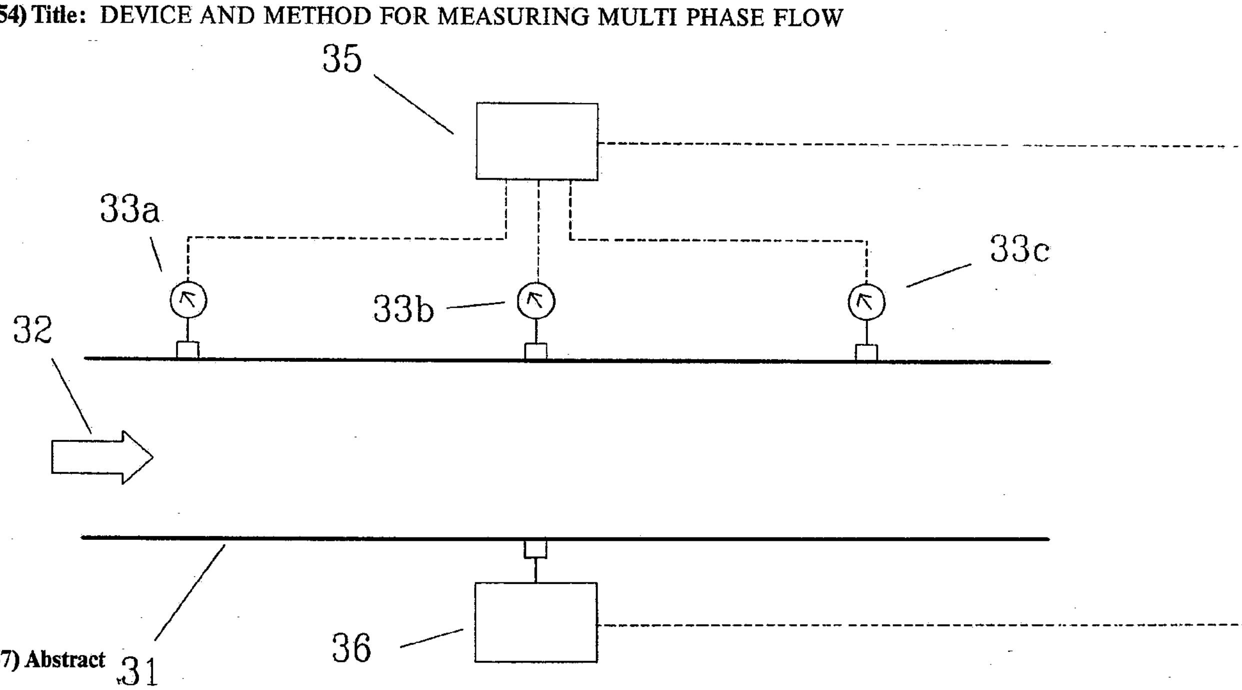

(57) Abstract

Device and method for measuring flow rate and gas/liquid fraction in pipes and wells, in which the flowing medium consists of several phases, particularly for two-phase systems of the natural gas/oil type. The device is characterized by a pressure pulse generator (36) to generate pressure pulses having a frequency of maximum 100 Hz into the medium, and two or more pressure sensors (33a; 33c), to register the low frequent pressure pulse generated in the pressure pulse generator (36), in which at least one sensor is located at a known distance down-stream of the pressure pulse generator and a second sensor located up-stream of the pressure pulse generator at a second known distance, the pressure pulse generator and the respective sensors communicating with a control unit (35) that receive and process the generated pressure pulse and the registered pressure pulses to determine the flow rate of the medium and the specific acoustic propagation speed.

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Device and method for measuring multi phase flow.

The present invention concerns an apparatus and a method for determining flow rate and gas/liquid ratio in multi-phase flows in pipes and wells, as stated in the introductory of claims 1 and 3, respectively.

Technical background.

US Patent 4,312,234 discloses the use of a twisted tape and a venturi. The pressure loss across each is measured. Mathematical and experimental (calibration) values are used to correlate the measured pressure losses to the mixture flow rate. The twisted tape is located immediately upstream to establish an annular shaped and homogenous flow through the venturi. This method depends on the use of a correct mathematical model with comprehensive calibration values. The method provides the mixture flow rate if the gas-liquid ratio is known. Moreover, this method requires an installation inside the pipe system, while the provision of the large number of required calibration values is very difficult.

US Patent 4,202,230 discloses an comparative filter correlating technique, in which several type of signals can be used: pressure, acoustic, optical, and others. Experimental values are required to identify the characteristic properties of the flowing phases. Two sensors pick up the signal and compare this with the characteristic properties. The propagation time for identical properties results in the flow rate. However, the method provides only the flow rates of individual phases and not the gas-liquid ratio. The present applicant is of the opinion that it is very difficult to obtain values for theses characteristic properties and that these properties are also liable to change between two metering stations.

US Patent 4,884,457 discloses two density meters, such as gamma ray meters. The measurements are correlated and compared with theoretical equations for a two-phase flow. However, such gamma ray meters are not able to provide a reponse that is sufficiently fast to detect the detailed flow properties which are required to cross-correlate the values.

Briefly, a variety of metering techniques for multi-phase systems have been proposed to measure flow rate and gas-liquid ratios. The problem is very complex

and has not been solved. A lot of new techiques are being developed, but the details of these are mostly unavailable.

A gamma ray meter can measure the density of a multi-phase mixture provided that the meter have been calibrated. Typically, the pipe is filled with the gas phase and the meter is calibrated, whereupon the pipe is filled with the liquid phase for calibration with respect to the latter. The equipment is then used to measure the reduction of intensity of the radiation that passes through the mixture of the two calibration fluids (gas and liquid). However, the calibration curve is necessarily not linear and thus it is not always possible to predict the calibration curve for mixtures. Experience from experiments with flowing gas-liquid mixtures is used to estimate the shape of the calibration curve. However, a considerable volume of experimental values is requried to obtain sufficiently accurate values for the real mixture density. This method provides only the gas-liquid ratio. For statistical reasons, this gamma ray instrument must measure the reduction of ray intensity during a certain period of time this it is not suited for the provision of momentary values. Several different gamma ray apparatus have been proposed, and such apparatus have been tested to overcome the difficulties connected with this technique. As mentioned above obtaining a sufficient amount of gamma rays to provide significant signals takes time (statistic of nucleous phenomena) and therefore such methods are, for that reason, not readily applicable to cross-correlation techniques.

The cross-correlation technique is used in several of the proposed multi-phase methods. The cross-correlation technique is based upon the measurement of a signal at two locations. These two signals are compared to obtain information about the propagation time between the two positions. Natural fluctuations form the basis of most of the cross-correlation techniques. These natural fluctuations are difficult to detect.

Capacitance methods are being developed to detect the mass flow of hydrocarbons and water in a pipe. However, such method is sensitive to water; i.e., the method measures the water flow rate, and assumes that the remaining flow is hydrocarbons. However, one can not distinguish between liquid hydrocarbons and gaseous hydrocarbons. Moreover, the capacitance method is influenced by the gas-liquid ration, thus claiming for a correction of the metering results in view of an

independent measurement for gas/liquid fraction, provided from e.g. a gamma ray meter.

Techniques using microwaves are being developed, and this is the latest contribution to this art. Microwaves are absorbed by water, and like the capacitance meter, one assumes that the remaining medium consists of hydrocarbons. The microwave technique (and the capacitance method) are also influenced by the gas/liquid ratio, accordingly a calibration is required. On the other hand, the microwave technique may be used for cross-correlation, but since the technique involves a large metering volume, only particular features of the multi-phase flow in a large scale are detectable.

The capacitance method and the microwave technique have substantially the same field of use, but do also have the same limitations.

In connection with research and in commercial applications, metering equipment consisting of two meters are being developed: a gamma ray meter and a capacitance or microwave meter. One of the meters provides the gas/liquid ratio and the other provides the amount of water. However, none of these are able to provide the flow rate in a multi-phase system.

Meters based upon the principle of gamma rays can be used to measure gas and volumetric liquid flowrates in a pipe. However, the accuracy of such metering is questionable as mentioned above. A substantial degree of calibration must be done to obtain good results. The gamma ray equipment can be used in the laboratory with accesories to calibrate the regularity of the equipment, but the application of such technique off-shore and with subsea installations has practical limitations. The gamma ray meter is not applicable to cross-correlation.

A capacitance meter is said to be applicable to the metering of water volume flowing with hydrocarbons in a pipe. The central question is the applicability of the capacitance meter to cross-correlation. The meter is said to be adjustable for such applications but, from the present inventor's point of view, this will become difficult. The technique is based upon a large metering volume; i.e. a pipe length that is several times longer than the pipe diameter. In such volume, it will be difficult to register anything other than the general properties of the flow (the flow characteristics). Thus, the capacitance method is applicable to cross-correlation in

flows having a coarse flow regime, such as liquid plugs. The technique can not be used for cross-correlation in a uniform bubble flow, and not with an annular shaped flow.

Many methods exist for determining the parameters of multi-phase systems, and at the present many are being developed.

Object.

The object of the present invention is to provide a single apparatus and a method to measure flow rate and/or liquid or gas fraction in multi-phase mixtures.

The invention.

The object above is achieved as stated in the characterizing part of claim 1 and 2. Further features of the invention appear from the dependent claims 3-8.

The present invention is based upon a principle of measuring propagation speed of a low frequency pressure pulse through the medium. The flow rate and the gas/liquid ratio in a multi-phase flow is, in accordance with the invention, provided by measuring the pulse propagation speed to a location up-stream of the pressure pulse source and to a second location down-stream of the pressure pulse source. The mixture flow rate can be determined directly by measuring the difference in pulse propagation speed between the pulse source and a metering point down-stream and upstream, respectively, in relation to the source, provided that the distance between the respective points are known. The gas/liquid ratio in a multi-phase stream is, in accordance with the present invention, determined indirectly from the real pulse propagation speed in the medium by subtracting the medium flow rate from the measured pulse speed. By providing information about the medium acoustic properties in advance, the measured pulse speed can be used to determine e.g. the liquid volume fraction in the multi-phase flow.

The propagation speed of a pressure pulse will vary in accordance with the compressibility of the medium. With respect to gas and liquid, the difference between their compressibilities is large. This difference also exsists in water/hydrocarbon systems. Accordingly, the present invention is also applicable to the metering of water volume in the hydrocarbon flow. The propagation speed of a

pressure pulse in a multi-phase system is typically in the range from 20 to 100 m/s; i.e., a measurement can be effected in a simple manner, such as with ordinary pressure transducers. The flow rate of multi-phase systems in a pipe is typically fom 1 to 10 m/s, and accordingly, metering results with great accuracy are in priciple achievable.

However, the present invention is not limited to systems of the gas/liquid type. The principle can also be used with other multi-component systems that exhibit different phases having different compressibilities, such as water/oil, emulsions and solids in liquid. Accordingly, the present invention has large potential and a broad field of use compared with known metering systems.

Experiments carried out in connection with the present invention have illustrated that if a pressure pulse is to be sufficiently propagated in such media the frequency has to be low. Pressure pulses having a frequency below 100 Hz are observed to be far less absorbed in the medium than at higher frequencies. The preferred frequency range will depend on the specific medium, but frequencies below 20 Hz are preferred, so that measurement across larger distances can be effected. If the pressure pulses are generated by expanding a small gas volume into the two-phase flow (e.g. with an injection pressure of about 10 bars), with e.g. a water/air system at a pressure close to atmospheric, measurement could be effected at a distance from 2 to 4 meters from the pulse source. Since such low frequent pressure pulses are not greatly absorbed in a flowing medium of this type, the metering method according to the invention is not substantially influenced by the flow pattern. This is a great advantage since the flow pattern can vary to a large extent in multi-phase systems.

As described above, determination of the medium flow rate can be done directly by subtracting the propagation speed from the pulse generator to a point up-stream of the generator and to a point down-stream of the generator. The pressure pulse will move down-stream with a speed equal to the specific acoustic propagation speed of the medium plus the medium flow rate. On the other hand, the pressure pulse will move up-stream of the pulse generator with a speed equal to the specific acoustic propagation speed of the flowing medium minus the flow rate of the medium. On the basis that the distance L_B and L_C from the pressure pulse generator to the respective metering locations (B) and (C), down-stream and up-stream of the pulse generator,

respectively, are known, the medium flow rate is determined according to the following formula:

$$V_{mix} = 0.5 * \left[\frac{L_B}{t_B} - \frac{L_C}{t_C}\right]$$

in which t_B is the pressure pulse propagation speed from the generator to the down-stream metering station B and t_C represents the pressure pulse propagation speed from the generator to an up-stream metering station C.

A determination of the phase fractions of the medium can be effected from a knowledge of the acoustic nature of the medium. If a metering principle according to the present invention is used with oil installations, numerical data for acoustic propagation speed of the respective phases must be provided. Numerical data for the speed of sound in natural gas is well known and is convenient to calculate for different process conditions, i.e. pressure, temperature and gas density. Acoustic propagation speed in the oil fraction can be correlated in view of pressure, temperature and pressure. In an adaptation to specific fields of use, making high demands on accuracy, it will be appropriate to carry out laboratory tests to establish a mathematical model. By metering pressure and temperature of the medium in addition to determination of the specific speed of sound, as stated above, the phase fractions can be calculated. In other situations it may be sufficient to apply available base values to establish a coarser reference with respect to the speed of sound. Even though the acoustic propagation speed will vary with pressure and temperature, the process conditions will, in most cases, be constant in the metering interval as described in further detail below.

The equipment.

In connection with a piping system, an apparatus according to the present invention can, for example, be provided as a pipe section having standard connections. This section is provided with a pressure pulse generator and at least two pressure recorders. A simple form of a pressure generator is based upon the principle of expanding a small gas volume into the flowing gas-liquid mixture to be measured. This gas must have a pressure above the pressure in the medium to be

measured. Such pressure pulse generator can, for example, comprise a gas tank, filled with a gas at a relatively high pressure, the gas tank being in flow connection with the pipe in which the metering occurs and separated from the pipe by a fast opening valve. By opening the fast opening valve the small gas volume will expand into the main pipe and generate a pressure pulse.

The pressure pulse is initialized when the valve is opened. Without any wish to be bound by a particular theory, the base mechanism behind the pressure pulse principle can, in general, be described as follow: At ideal conditions in a homogeous and stationary medium, an oscillating gas (such as nitrogen) bubble will be produced. When the bubble escapes into the homogenous medium, the pressure inside the bubble will be higher than of the environment. Because of this gauge pressure, the bubble will expand to neutralize the pressure difference between the bubble and the environments. This pressure equalization is a dynamic process, and accordingly, the bubble will oscillate with a decreasing amplitude until equilibrium is realised. However, in reality, a lot of different media, as stated above, exist locally in a multi-phase medium, so that an injected gas bubble will generate pulses with a spectrum of frequencies that propagate in the bulk phase. In a metering system according to the present invention, pulses having the desired frequency, preferably as low as possible, are filtered away by means of a metering and control unit.

In an alternative way of generating pressure pulses, a bendable ferritic membrane can be provided in the pipe wall in a main plane substantially parallel with the longitudinal axis of the pipe. A coil, located adjacent to the membrane, can produce a short duration magnet field to effect a temporary bending of the membrane. In this way, a pressure pulse can be created directly into the medium to be metered. An alternative mode of generating pressure pulses is to apply a vibrator means, e.g. of the type used in seismologic research.

A person skilled in the art will naturally find the appropriate method to establish such pressure pulses and the present invention should not be regarded as being limited to either high pressure gas injection nor ferritic membranes, as suggested above.

The pressure recorders can for example be based upon a simple pressure metering apparatus, such as a pressure transducer. The general requirement of the pressure

recorders is that they have to exhibit as short response time as possible and that they are adapted to a metering pressure range in conformity with the metering systems in question.

A metering apparatus according to the present invention can alternativly be formed as a probe to be inserted and fixedly mounted by, for example, logging tools of known type, inside a pipe or a well. The metering apparatus can consist of two membranes and two pressure recorders mounted on a, e.g. two meter long, probe in the form of a rod or the like. Preferably, a membrane and a recorder are mounted at each side of the respective ends of the probe. The membranes can be adapted to vibrate at different frequencies, such as 8 Hz and 16 Hz, and the recorders can register the pressure continously. The pressure data can then be filtered to provide signals only from the membrane at the other side of the probe as input values for the calculation of pulse speed.

The pulse speed can be measured continously by alternating between 8 Hz and 16 Hz for the two membranes. When the signal from the membrane at the other side of the probe has ben received, the frequencies can be altered. By alternating between 8Hz/16Hz and 16Hz/8Hz, respectively, pulse speed across the same pipe segment can be measured continously. By continously measuring down-stream and up-stream pulse speed across the same pipe segment, the data basis for the determination of flow rate and gas/liquid fraction will be very good.

Brief description of the Drawings.

In the following, the present invention is described in further detail with reference to drawings, in which

Figure 1 illustrates a metering arrangement according to the present invention,

Figur 2 is a diagram showing the time lag between generated pressure pulse and measured pressure pulse,

Figure 3 illustrates an alternative metering arrangement according to the present invention,

Figur 4 is a diagram showing the pressure pulse-response with respect to the pulse frequency in a water-air system provided in accordance with the present invention,

Figure 5 is a diagram illustrating theoretical variation in pressure pulse speed with

respect to the mass fraction of air in a two-phase system comprising water and air,

Figure 6 shows pressure pulse response with respect to pulse frequency in a two phase system consisting of water and air, and

Figure 7 illustrates schematically an alternative metering arrangement according to the invention in the form of a probe to be inserted into a pipe section or a well.

Detailed description of the invention.

Figure 1 shows an example of a metering arrangment consisting of a pipe 11 in which the flow direction of the two phase flow is indicated by the arrow 12. The pulse generator is, in this embodiment illustrated, as a gas tank 16 that contains e.g. nitrogen at a pressure higher than the pressure of the medium inside the pipe 11. The gas tank 16 communicates with the pipe 11 via a control valve 14a and is provided with a pressure sensor 13 to detect the gas pressure in the tank 16. Refilling of gas is regulated by means of a valve 14b. At the diametrical opposite side of the pipe 11 (in this example), a pressure sensor 13a is provided to register the generated pressure pulse from a relatively small gas volume being expanded into the pipe 11 from the gas tank 16 via control valve 14a. However, the pressure sensor 13a can be located at angle of e.g. 45° from the pressure pulse generator with respect to the pipe cross section, provided that it is located in the vicinty of the origin of the pressure pulse. A corresponding pressure sensor 13b is located down-stream of the pulse generator and the sensor 13a. A metering and control unit 15 communicates with the pressure sensors 13, 13a and 13b including the control valves 14a and 14b. The metering and control unit 15 initiates a pressure pulse in the pipe 11 by injencting a small gas volume at relatively high pressure by a quick and short opening of the control valve 14a. The generated pressure pulse is sensed at the pressure sensors 13a and 13b which send a signal to the metering and control unit 15. By means of this arrangment, specific speed of sound in the two-phase flow can be measured by using the propagation speed from the pulse generator to the sensor 13a as reference point.

Figure 2 shows generally the loss of intensity and time lag of the generated pressure pulse (solid line) and the measured pressure pulse (stippled line). The propagation speed of the pressure pulse from the generator to the sensor can me measured at several locations, e.g. at the pulse maxmimum or the wave front. If the

distance between the pulse generator and sensor is known the pulse propagation speed can be found directly. This speed will naturally vary with, among other things, the flow rate of the medium. As appears from the diagram, the measured pressure pulse has a lower intensity than the generated one. This absorption increase with increasing pulse frequency is discussed in further detail below with reference to Figure 4. Moreover, the pulse maxima are rounded off. This is because the pressure pulse disperses to a certain degree in the medium, in which the pulse propagates faster in the liquid phase compared with the gas phase.

Figure 3 shows an alternative metering arrangement according to the present invention for the metering of void fraction and flow rate in a two-phase flow. The pulse generator is in this embodiment denoted generally at 36 and can, for example, comprise either a gas injection system as indicated in Figure 1 or a vibrating membrane as discussed above. The directon of flow of the two-phase medium is indicated by arrow 32. Three pressure sensors 33a, 33b and 33c are located up-stream, opposite and down-stream of the pulse generator 36, respectively. The pulse generator 36 and the respective pressure sensors all communicate with a metering and control unit 35. As discussed above, the flow rate of the medium can be determined directly by subtracting the pressure pulse propagation speed up-stream, i.e. from the pulse generator 36 to the pressure sensor 33a up-stream, from the pressure pulse propagation speed down-stream, i.e. from the pulse generator 36 to the pressure sensor 33c down-stream, provided, of course, that the distance between the respective locations are known.

In Figure 7, a probe is indicated as being inserted into a pipe section 71 as described above. The probe, here generally denoted by 72, comprises pulse generators 73a and 73b located at opposite ends of the probe, and two pressure sensors 74a and 74b located in the opposite ends of the probe and adjacent to the respective pulse generators. The pulse generators are preferably ferritic membranes that vibrate continously at a desired frequency, induced by means of an electromagnetic coil. The probe length can be adapted to the actual need, but typically, the length may vary from 2 to 4 meters. The membrane can, as mentioned above, be adapted to vibrate at different frequencies, for example alternating between 8 and 16 Hz. By filtering the registered pressure data, thus using only the signals

from the membrane at the opposite end of the probe as input values for the calculation of pulse speed, a metering of both up-stream and down-stream pulse speed across the same pipe segment can be effected, thus providing a good basis to determine both gas-liquid fraction and flow rate.

This alternative configuration is particularly suited for well bore installations, in which the probe is simply inserted into the well bore and located at a desired position by means of ordinary available tools, optionally together with other tools that is commonly used with well logging. Communication with the surface can be done e.g. by means of an ordinary electric logging cable

Example 1.

In order to illustrate the invention in further detail, experiments were carried out with a two-phase system consisting of water and air.

The appratus consisted of a plastic pipe, a pulse generator, pressure sensors and a PC. The main element of the appratus was a ca. 50 meter long pipe circuit, of which 25 meter in each direction, having an inner diameter of 4.26 cm. The pipe circuit was constructed of transparent PVC plastic to be able to monitor the flow regime in the two-phase flow. The fluid mixture flowing through the pipe was transported by means of a compressor and a water pump respectively for air and water separately. The water was circulated from a 2 m^3 water vessel via a mixing unit and a stabilizing unit through the pipe circuit via a separator and back to the water vessel. The rate was controlled by means of a manual butterfly valve. The air was supplied by a compressor. The air pressure could be controlled by a reduction valve, and the rate could be controlled by means of three manual butterfly valves; one for small, one for medium, and one for large rates.

Magnetic flow meters and rotameters were used to measure the in-flowing fluids. The flow rate of water was measured with a magnetic flow meter and three rotameters. The magnetic flow meters were directly connected with a PC, whereas the rotameters could only be read manually. The air rate could be measured by means of three magnetic flow meters and four rotameters. The air pressure of the in-flowing air was measured by means of an oil-filled manometer. After the separately in-flowing phases were measured, the phases were intermixed to form a two-phase

fluid in a V-fitting and transported through the horizontal pipe section.

To effect the necessary measurements, a 5 meter long pipe section was removed from the circuit and replaced by a new section that was, in principle, formed as shown in Figure 3. However, the metering station consisted of a pulse generator and pressure sensors that could be selectively located in the 9 sensor holds. The pressurized air container consisted of a ca. 8 cm long 16 bar PVC pipe having an inner diameter of 4 cm, that was adapted to inject a pulse creating nitrogen volume of about 5 cm^3 into the main pipe. The pressurized air vessel was connected with a nitrogen tank via a valve, thus enabeling pressure regulation from 1 to 16 bar. The pressure valve of the pressure pulse generator, cf. the valve 14a of Figure 1, was a solenoid valve having a bore diameter of 10 mm. Two types of pressure sensors were used: 1 bar and 5 bar sensors. The output signals from the pressure sensors were guided via a amplifier and a digitalisating unit, and registered in a PC. The pressure was registered with a sampling rate of 300 Hz. The metering section was located as far down-stream from the mixing unit as possible so that the two-phase fluid obtained the longest possible flow path prior to metering. The flow pattern was thus fully developed prior to the metering station.

Measurements were carried out for different gas/liquid conditions and different flow rates by injecting 5 cm^3 nitrogen volumes into the main pipe, in which the nitrogen pressure was varied from 6 to 12 bar. The pressure of the two-phase flow was close to atmospheric. The results of these experiments are illustrated in Figure 4, that shows the pulse speed in m/s in view of mass fraction air based upon counter current metering. Figure 5 shows theoretical values corresponding to Figure 4 calculated according to Kieffers model (Kieffer S.W., 1977; Sound Speed in a Liquid-Gas mixture; Water-Air and Water-Steam. Dep. of Geol., Univ. of Cal., LA). The values in Figure 4 measured according to the present invention exhibit surprisingly good correspondance with the theoretical values. This illustrates that the present invention can be used for the metering of volume fractions of the respective phases in a two-phase flow.

Likewise, the medium flow rate can be calculated, as dicussed above, by substracting down-stream pulse speed from up-stream pulse speed. The measurements should be carried out simultaneously across both (or more) of the

pressure sensors up-stream and down-stream the pulse generator and across the same pipe segment.

Example 2

In order to illustrate the influence of the frequency range for the pressure pulse, a test corresponding to Example 1 was conducted. Fig. 6 discloses a summary of these tests for an air dominant flow regime having a pulse response as a function of pulse frequency. These values originated from a FFT-routine (Fast Fourier Transform). As seen in the Figure, the pulse response declines to a practically non-detectable signal at a pulse frequency of approximately 50 Hz. This emphazises the importance of using correct pulse frequency to obtain results that are useful.

Furthermore, the pulse response for a fluid dominated flow regime has a tendency to exhibit a positive shift. This means that the measuring sensor registers a higher main frequency than the reference sensor. On the other hand for air dominated flow regimes a negative response shift is observed. This means that the measuring sensor registers a lower main frequency than the reference sensor. The response shift within the frequency range is also to a great extent a fluid characteristic for a two-phase fluid. In other words, this characteristic can determine the fraction composition of the two-phase medium.

In addition, the frequency analysis contains much other information which can be utilized for determining characteristics for a two-phase flow.

Claims:

1. Method for determining flow rate and quantity ratio between different phases in pipes and wells; the flowing medium comprises two or more phases, particularily for two-phase systems of the natural gas/oil type, wherein a sound wave is generated at a location (36) in or in the vicinity of the pipe or the well;

the sound wave is registered at a first location (33c) in the flow direction from the location (36) for the generated sound wave, and the sound wave is registered at a second location (33a) opposite the flow direction from the location (36) for the generated sound wave, wherein the distances between the locations (36) where the sound wave is generated and the respective measuring first and second locaions (33c and 33a) are denoted by lengths L_c and L_a;

the time difference between the propagation time of the pressue pulse, t_1 and t_2, respectively, through the medium from the location (36) to the first and second location (33c) and (33a), respectively, is used for determining the flow velocity of the medium according to following formula:

$$V_{mix} = 0.5 * \left[\frac{L_B}{t_B} - \frac{L_C}{t_C}\right]$$

wherein v_{mix} denotes the flow velocity of the composition;

c h a r a c t e r i z e d by the sound wave transmitted from location (36) into the flowing medium in the pipe or the well is generated with a frequency less than or equal to 100 Hz, and optionally determining the gas/fluid ratio in the medium by subtracting the absolute flow velocity of the medium from the measured propagation velocity, whereafter comparison is made with the true propagation velocity using theoretical or experimental values.

2. Method according to claim 1,

c h a r a c t e r i z e d by the sound wave is generated as discrete pressure pulses.

3. Device for determining flow rate and gas/fluid ratio in pipes and wells where the flowing medium comprises two or more phases, particularily for two-phase systems of the natural gas/oil type, comprising a generator (36) for generating sound waves into the medium, and two or more sensors (33a;33c) for registering sound

waves generated in the generator (36), at least one of the sensors being located at a known distance in the flow direction from the generator, and a second sensors being located at a second known distance opposite the flow direction from the generator, and the respective sensors (33a;33c) are all connected to a control unit (35) which can receive and process the generated sound wave and the registered sound waves for determining the flow velocity of the medium and the specific acoustic propagation velocity,

characterized by the generator (36) and associated sensors (33a;33c) being adapted to respectively generate and register sound waves having a frequency less than or equal to 100 Hz.

4. Device according to claim 3,

characterized by the generator (36) and associated sensors (33a;33c) are adapted to respectively generate and register sound waves in the form of discrete pulses.

5. Device according to claim 4,

characterized by the generator comprising a gas tank (16) containing a gas at a pressure higher than the pressure of the medium to be measured, the tank being in fluid communication with the flow duct housing the medium to be measured, the gas tank and the duct being separated by a fast opening valve that, when opened, expands gas into the medium to be measured, thus establishing a pressure pulse in the same.

6. Device according to claim 4,

characterized by the generator (36) comprising a bendable ferritic membrane located in the duct wall in a main plane being substantially in parallel with the longitudinal axis of the duct, and an associated coil located adjacent to the membrane to create a short duration magnet field to provide a temorarily bending of the membrane, thus creating a pressure pulse directly into the medium to be measured.

7. Device according to one of claims 3 to 6,

characterized by the generator (36) being adapted to generate pressure pulses having a frequency below 20 Hz.

8. Device according to one of claims 5 to 7,

characterized by the generators (73a;73b) being integrated in a probe (72) in the form of a pipe or the like, each generator being located at opposite ends of the probe (72), in which two pressure sensors (74a,74b) are located at opposite ends of the probe and adjacent to the respective generators.

9. Device according to claim 8,

characterized by the generators (73a,73b) is adapted to operate at mutually different frequencies.

10. Device according to claim 9,

characterized by the respective generators (73a,73b) being adapted to generate pressure pulses at two mutually different and alternating frequencies.

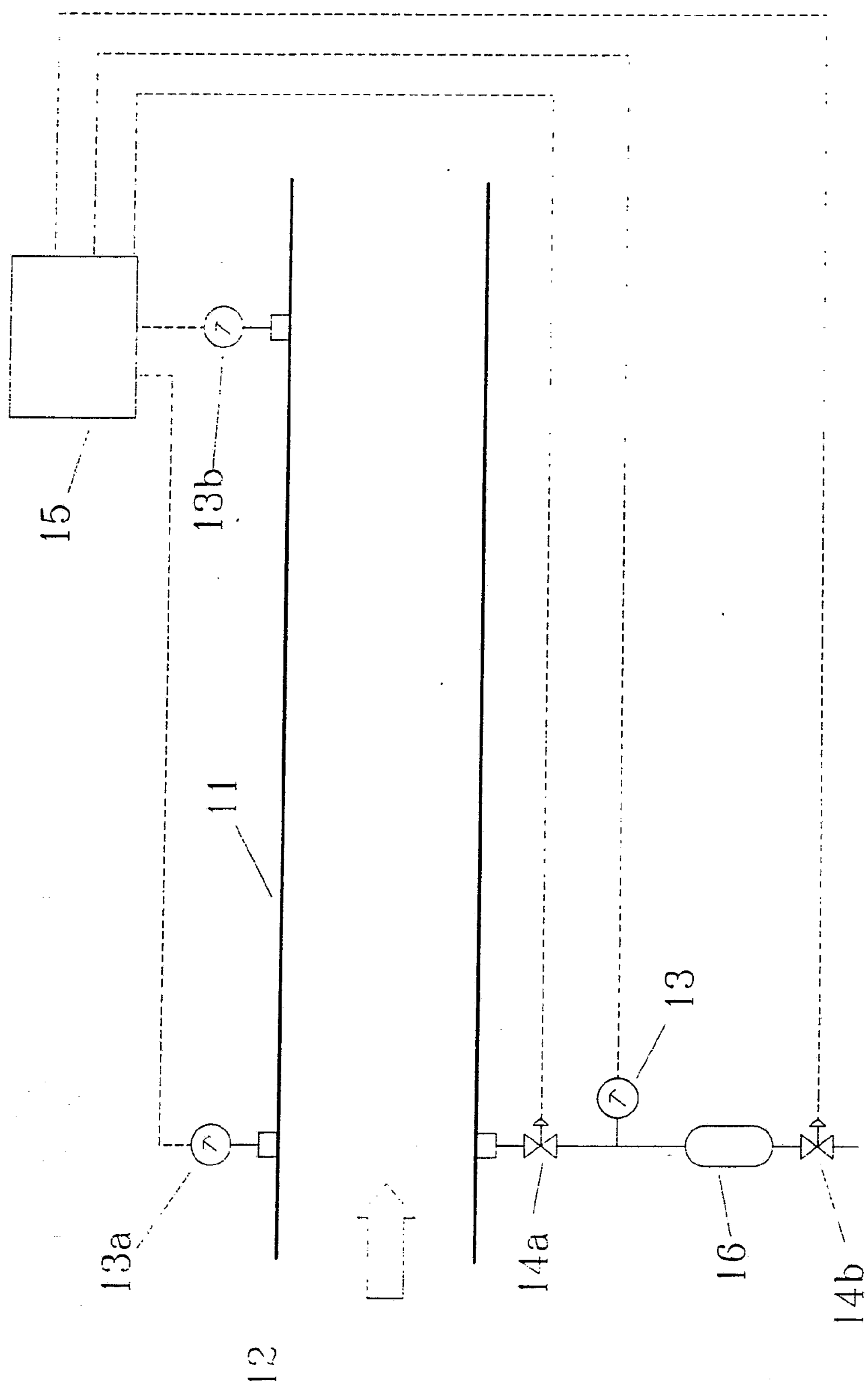


Fig. 1

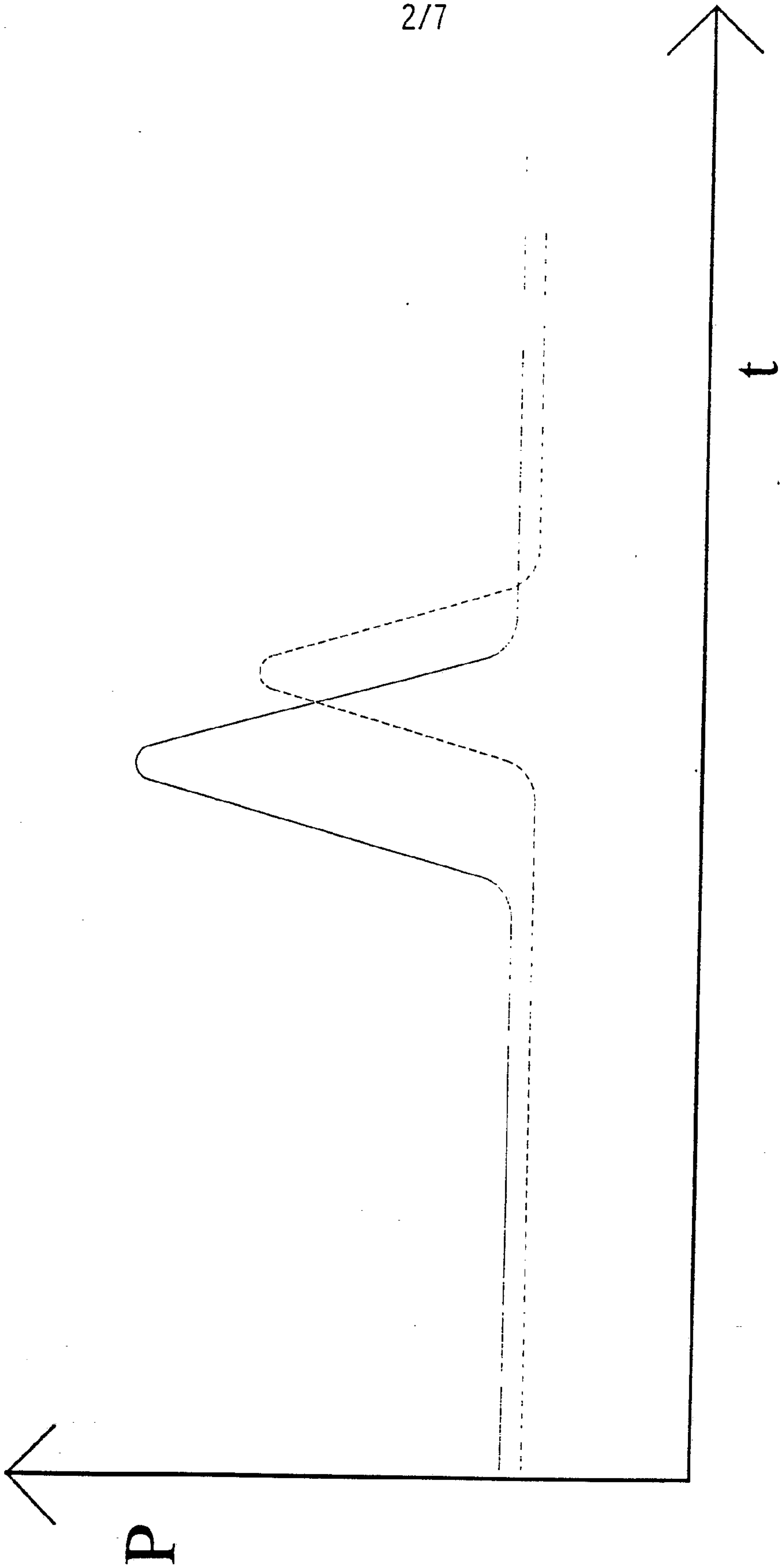


Fig.2

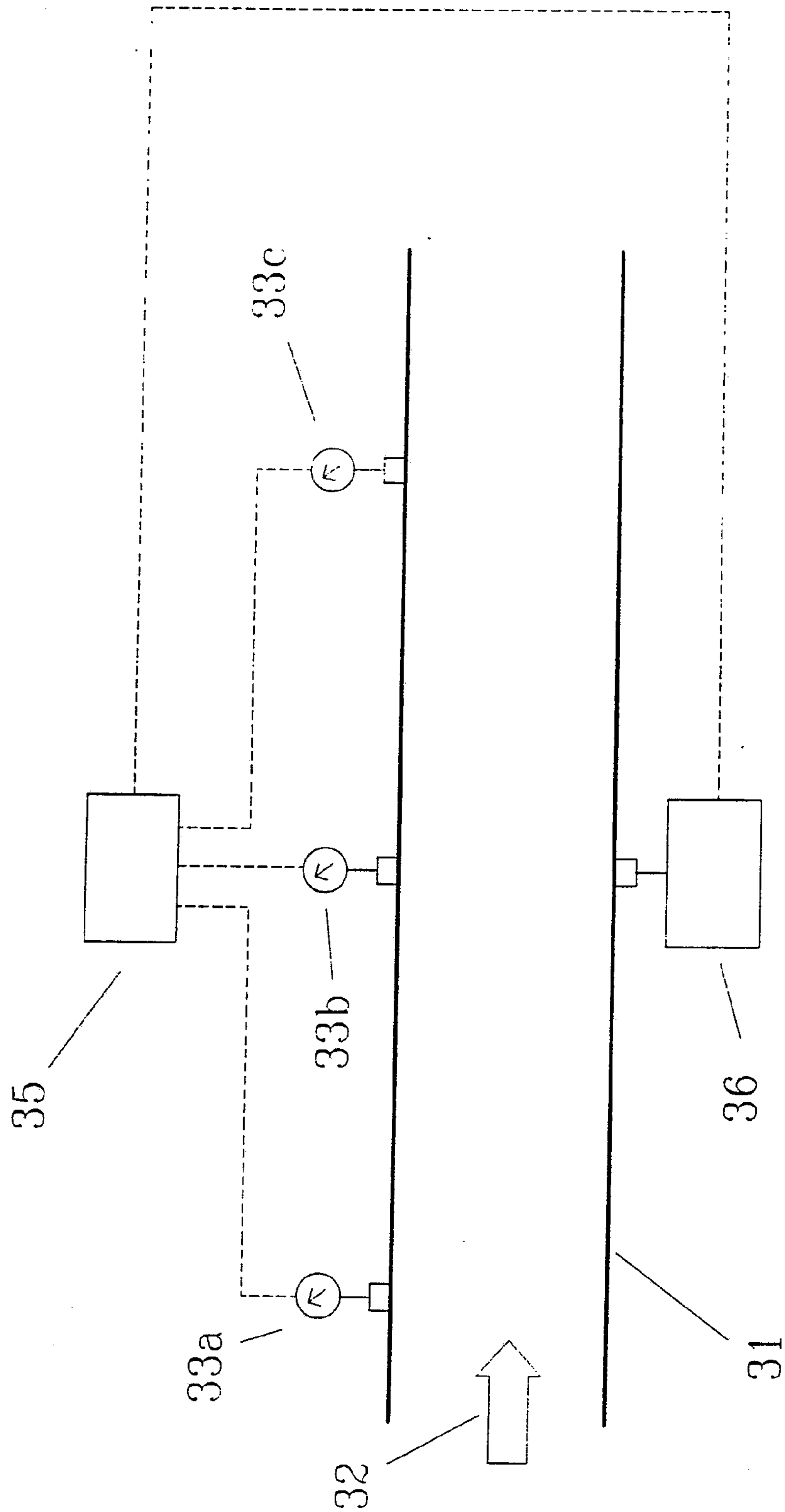
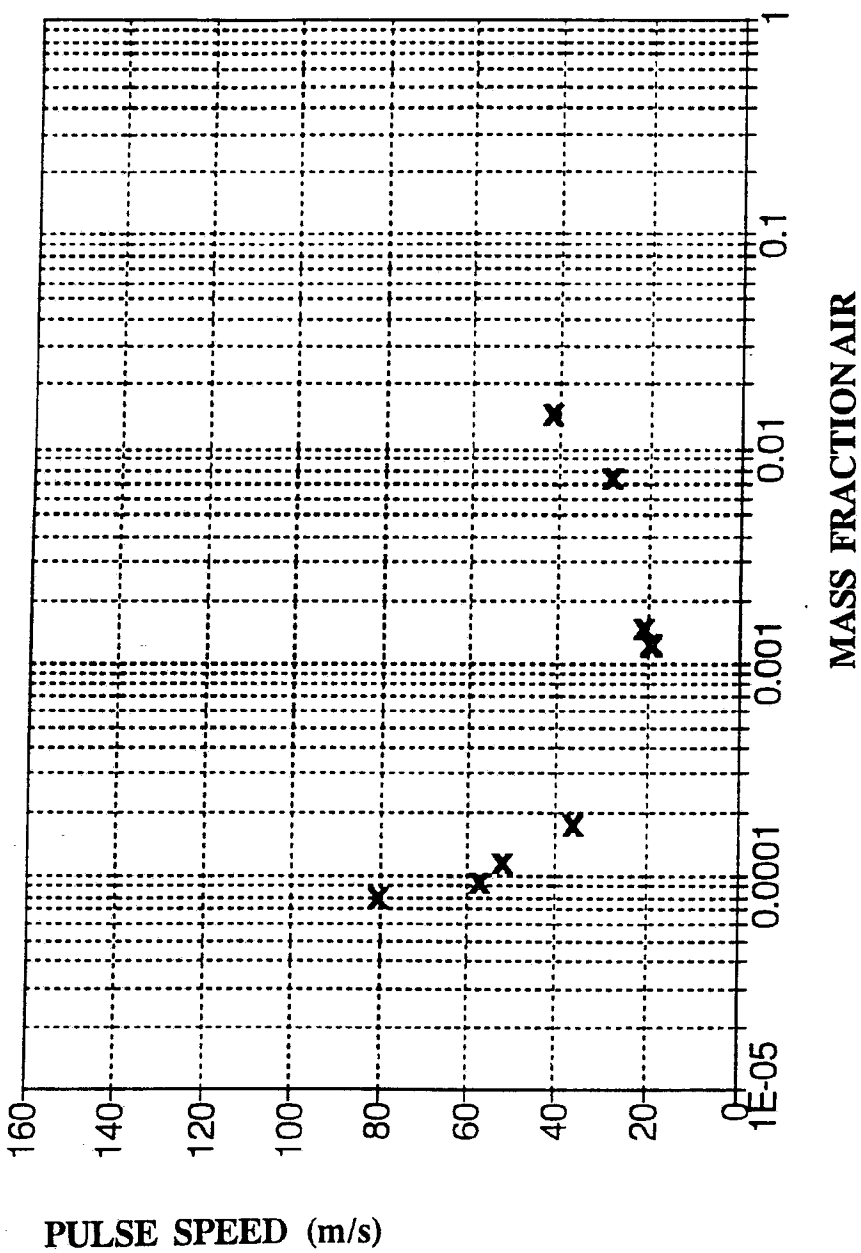


Fig. 3


MASS FRACTION AIR
PULSE SPEED (m/s)
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140
120
100
80
60
40
20
0
1E-05
0.0001
0.001
0.01
0.1
1

Fig. 4

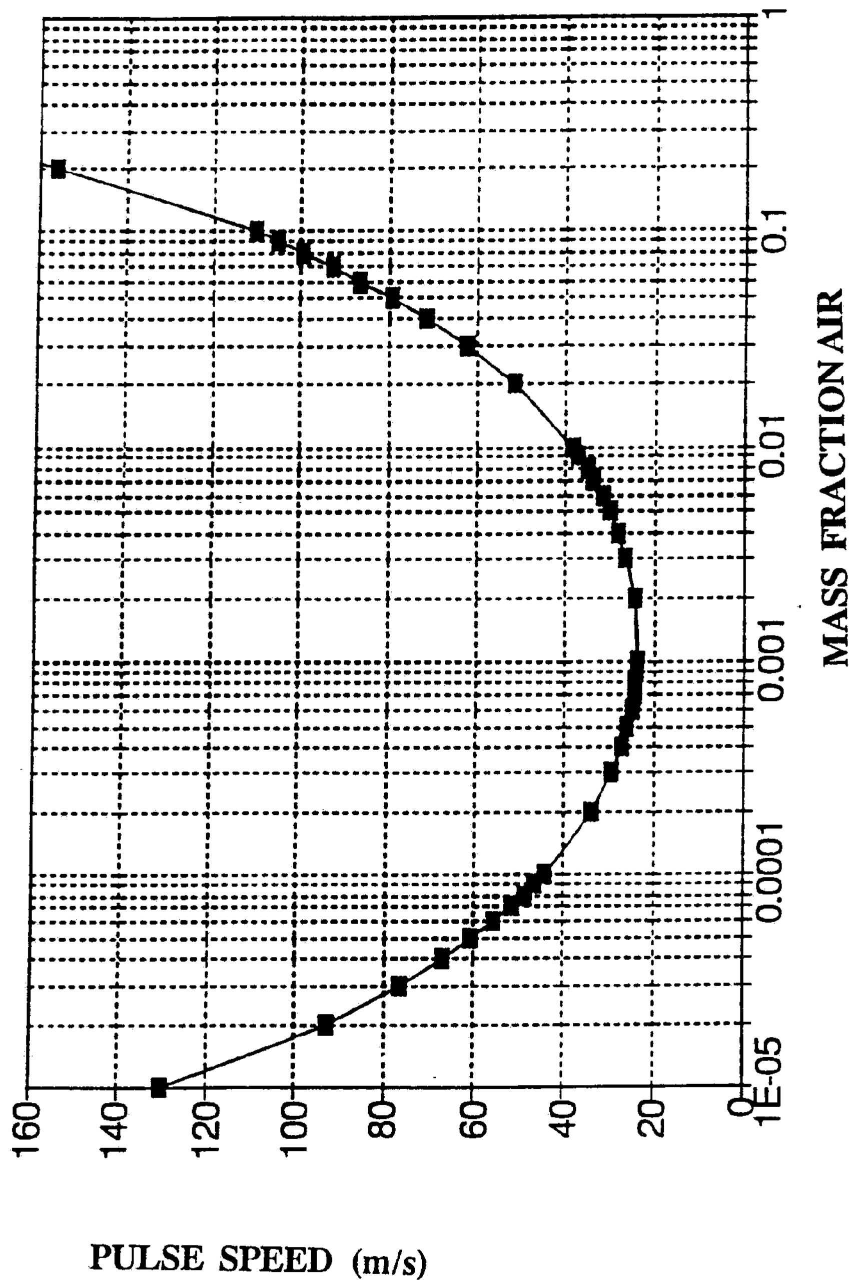
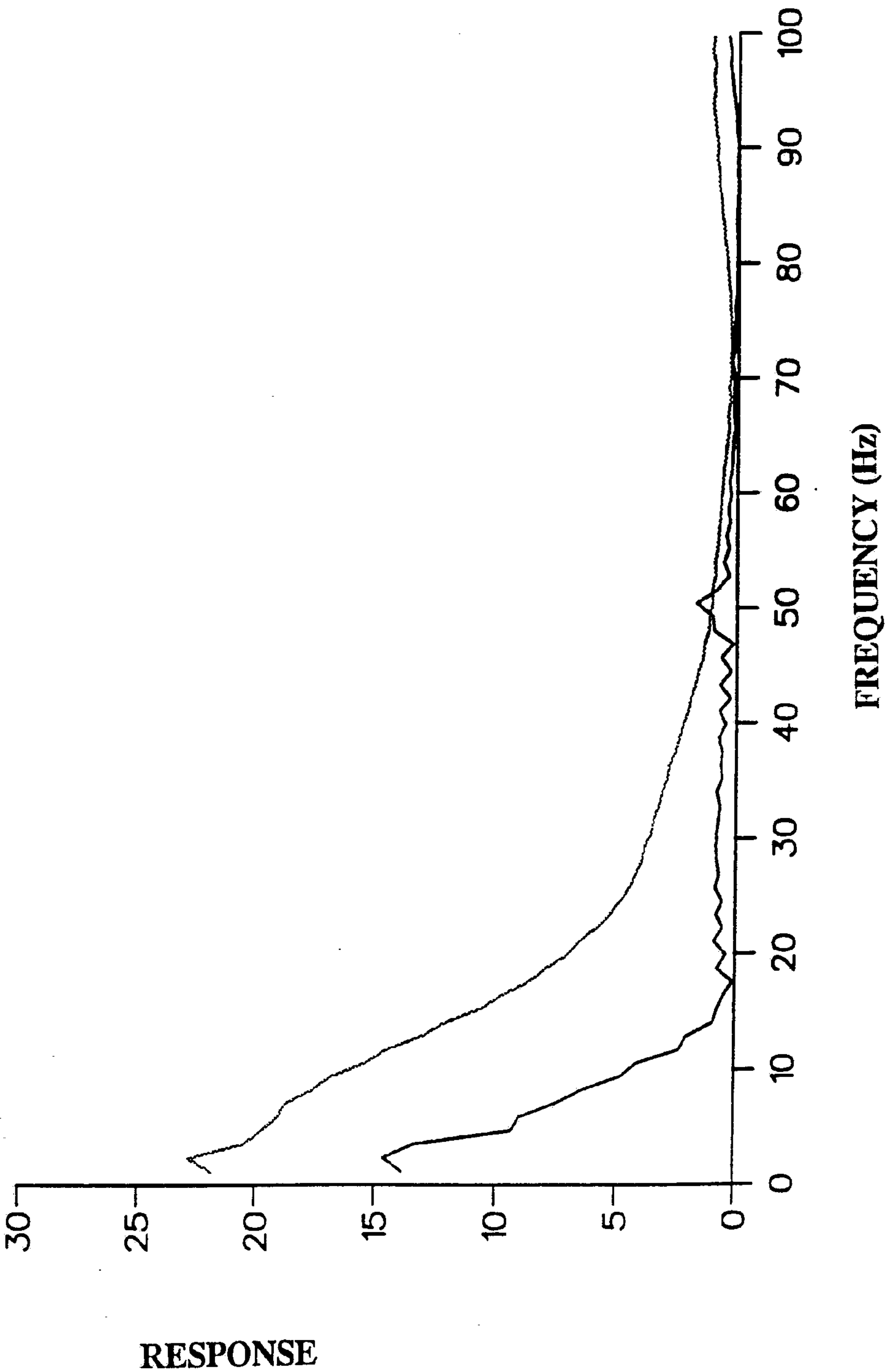

PULSE SPEED (m/s)
160
140
120
100
80
60
40
20
0
MASS FRACTION AIR
1E-05
0.0001
0.001
0.01
0.1
1

Fig. 5


RESPONSE
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5
10
15
20
25
30
FREQUENCY (Hz)
0
10
20
30
40
50
60
70
80
90
100

Fig. 6

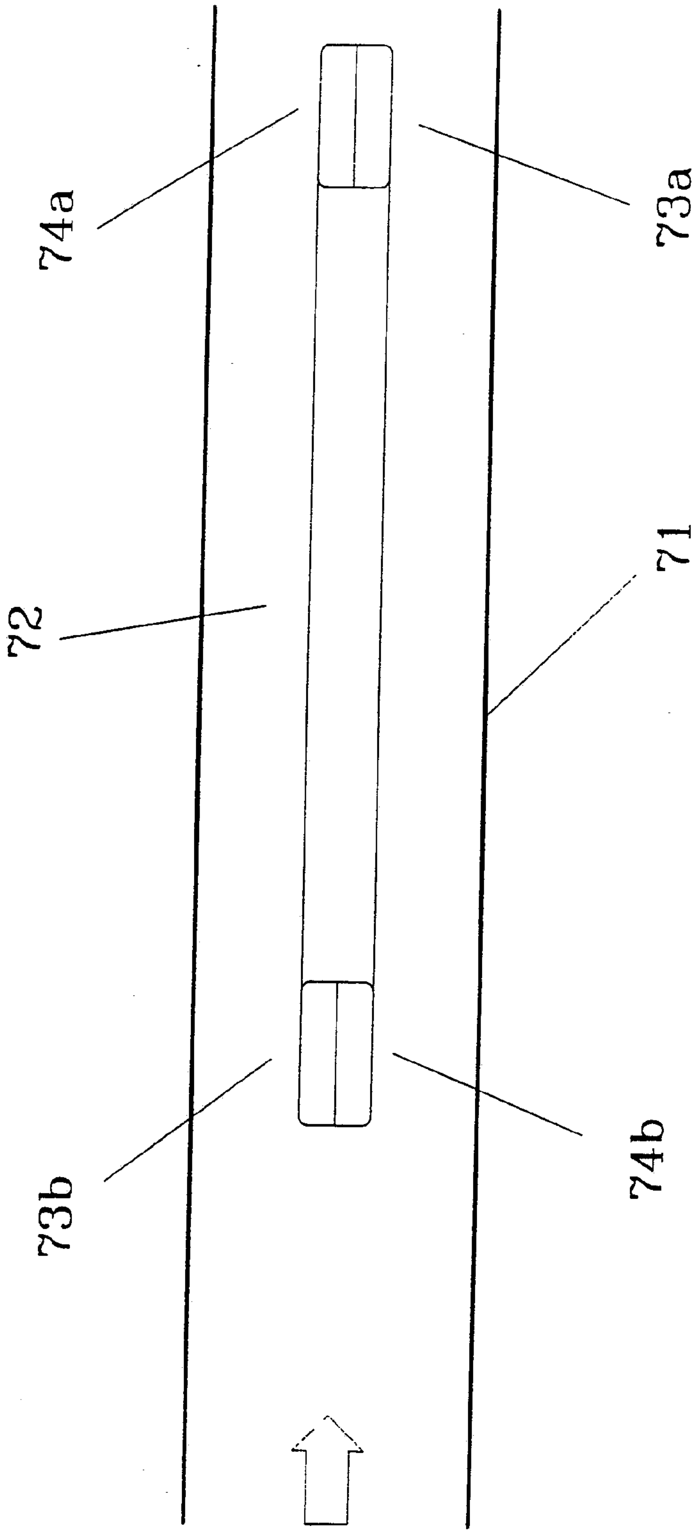

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 93/00001

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: G01F 1/66, G01F 1/704, G01P 5/18, G01N 29/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC5: G01F, G01N, G01P

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US, A, 3496771 (E.M.MOFFAT), 24 February 1970 (24.02.70), column 1, line 35 - column 2, line 12	1,2
Y		3-5
	--	
Y	US, A, 3469445 (E.M.MOFFAT), 30 Sept 1969 (30.09.69), claim 14	1-5
	--	
Y	US, A, 3514071 (E.M.MOFFAT), 26 May 1970 (26.05.70), column 1, line 38 - line 49; column 2, line 8 - line 55	5
	--	

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:
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"E" erlier document but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 April 1993	21 - [illegible]
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Harriet Ekdahl Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NO 93/00001

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US, A, 2151203 (H.E.HARTIG), 21 March 1939 (21.03.39), page 2, line 15 - line 40 --	1-4,6
Y	FI, B, 76885 (VALTION TEKNILLINEN TUTKIMUSKESKUS VTT), 31 August 1988 (31.08.88), page 8, line 31 - page 9, line 5 --	1-6
A	CH, A, 669463 (W.GUGGENBüHL), 15 March 1989 (15.03.89), claims 1,4,5 -- --------	1-10

INTERNATIONAL SEARCH REPORT
Information on patent family members

26/02/93

International application No.
PCT/NO 93/00001

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 3496771	24/02/70	NONE	
US-A- 3469445	30/09/69	BE-A- 718212	31/12/68
		DE-A,C- 1773777	13/04/72
		FR-A- 1576056	25/07/69
		GB-A- 1189555	29/04/70
		NL-A- 6809601	22/01/69
US-A- 3514071	26/05/70	NONE	
US-A- 2151203	21/03/39	NONE	
FI-B- 76885	31/08/88	NONE	
CH-A- 669463	15/03/89	NONE	